Bed Sensor Alarm

Final Presentation

Team 35

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ECE 445

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Introductions:

Colby King

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Senior in EE

Ebaad Siddique

Senior in EE

Problem

Everyone loves the snooze button, right?

What is stopping me from turning off my alarm and going right back to bed?

What if your bed could detect your weight and know when you actually stepped off?

Solution: Bed Sensor Alarm!

- Use weight sensors between the bedframe and mattress to detect when the user is in and out of the bed

- System will have an alarm clock with user input that can set both the alarm time and the clock time

- When the user is out of bed and presses the snooze button:

    - Snooze Button: pressed to turn alarm off temporarily for 5 min
    - Weight sensors should sense a person within 5 min for alarm function to continue

High-Level Requirements:

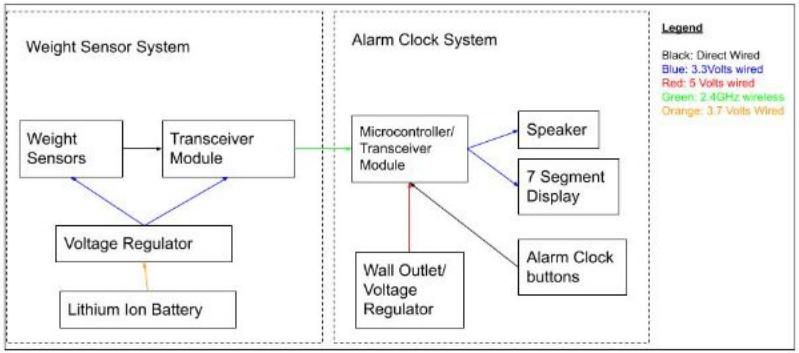
- System should have 3 states:
    - Regular Standby mode —> Normal Clock Operation
    - Alarm Mode —> For Alarm sound and snooze button
    - Timer Mode —> Snooze button and timer starting

- Sensors wirelessly share weight data with alarm and sense when 50lb weight is removed from bed

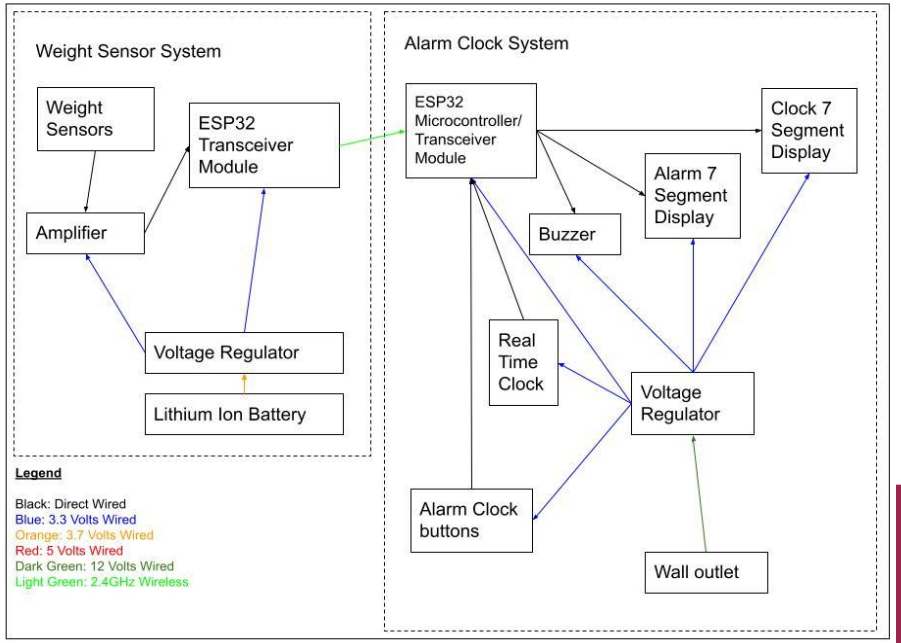
- Snooze button pressed —> system returns to alarm mode if 50lb is added back before timer goes off.

Brief Review of Original Design/Changes:

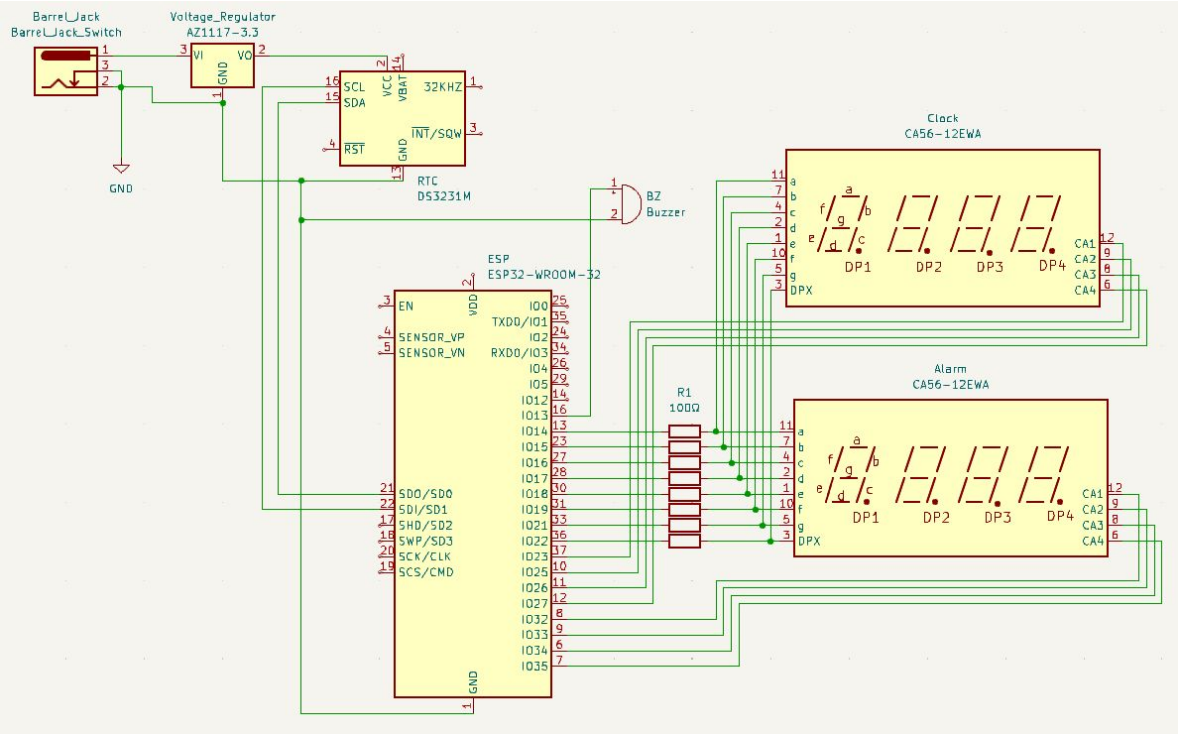
Before



After

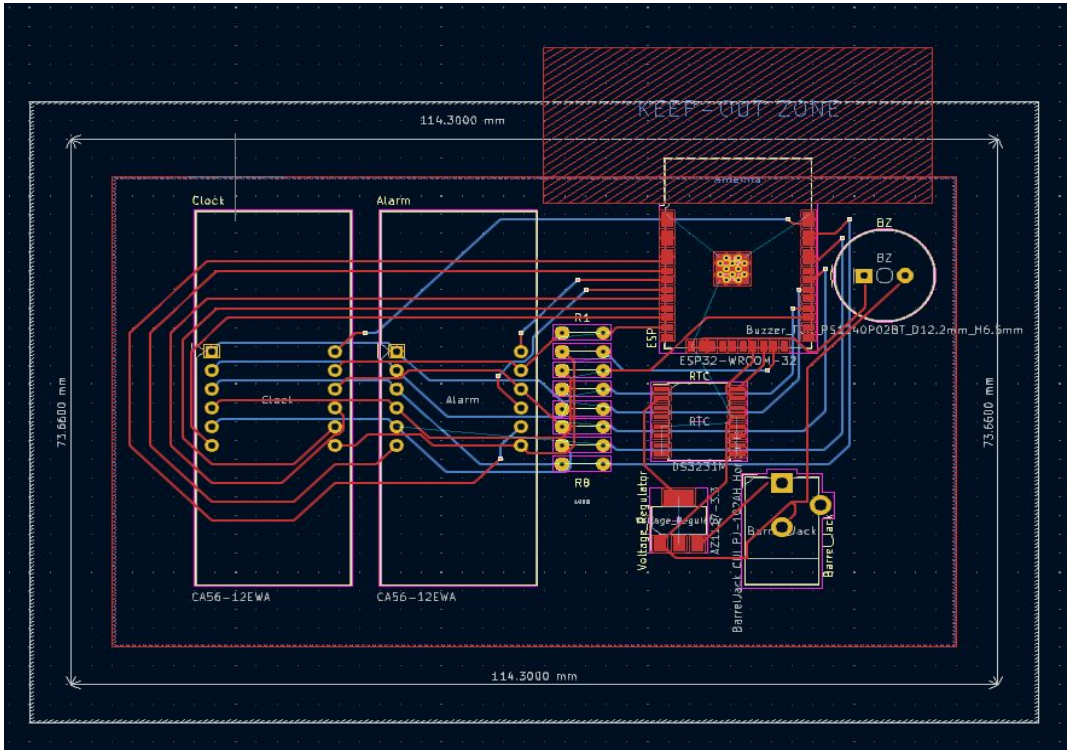


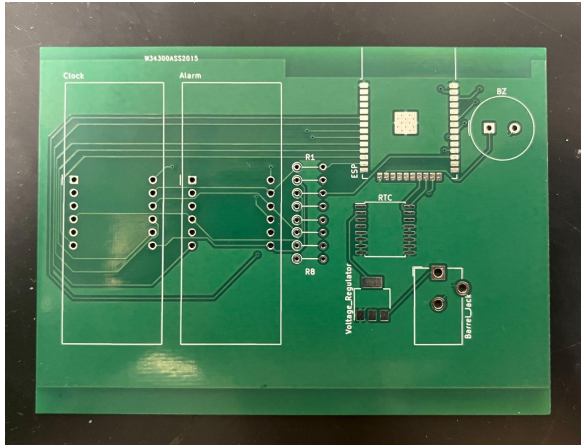
PCB Schematic Design:



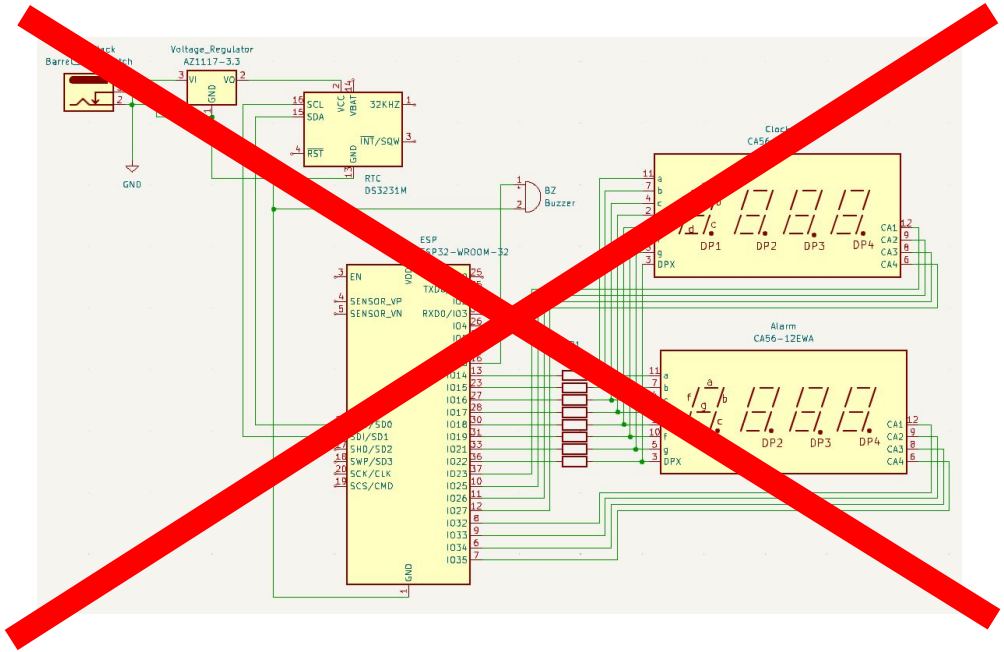
Updated alarm clock system design

PCB Design:

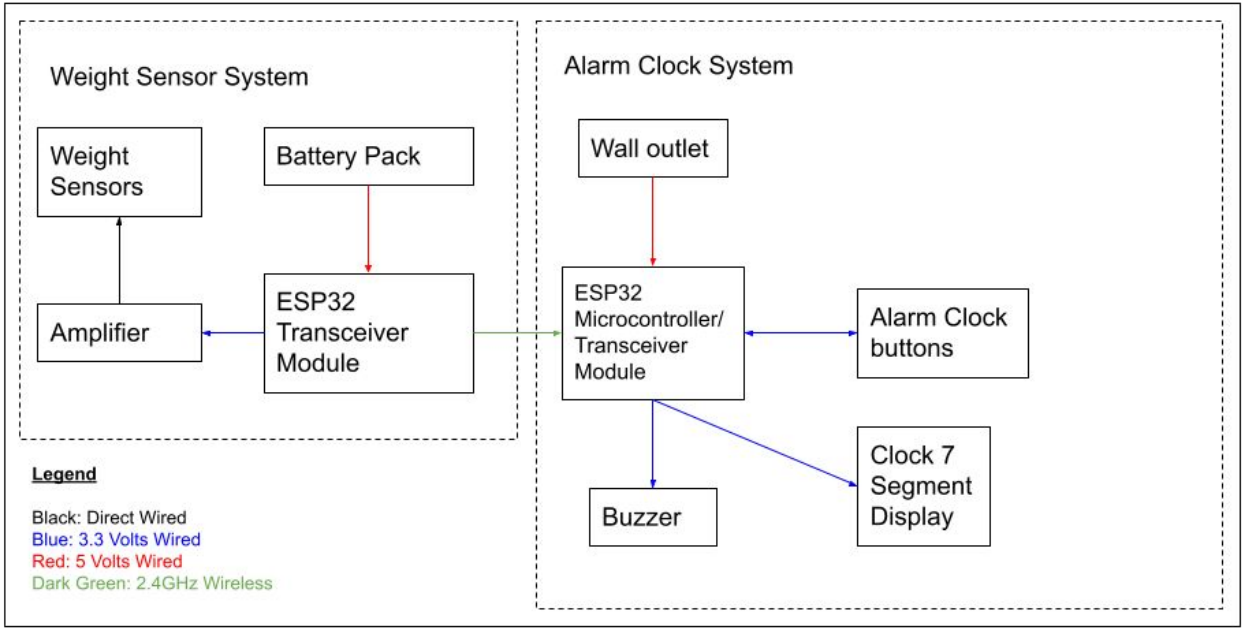

KEEP-OUT ZONE
Antenna
114.3000 mm
73.6600 mm
Clock
Alarm
BZ
R1
ESP
ESP32-WROOM-32
RTC
DS3231M
R8
Voltage_Regulator
BarreJack
CA56-12EWA
CA56-12EWA
114.3000 mm


Clock
Alarm
BZ
R1
ESP
RTC
R8
Voltage_Regulator
Barrel_Jack

What Happens When Parts Don’t Arrive?



Final Design Block Diagram



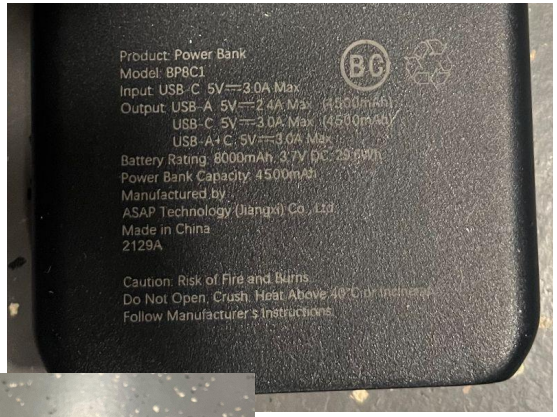
Removed

Voltage Regulators

Real Time Clock

Batteries

Weight Sensor System



Power

- ESP32 powered by 5V battery pack

- ESP32 outputs 3.3V to pins

- Weight sensors/ Amplifier operates at a range of 3.3V to 3.7V

*ESP32 operates at max current of 500mA

Weight Sensor System

Weight Data

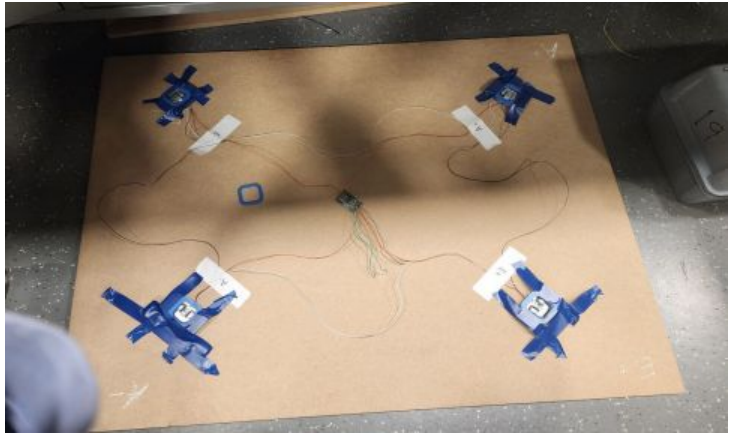
- Arrangement of load cells on board ensures accurate weight distribution

- 3D printed load cell mounts for stability

- Sensor System consists of multiple load cells connected to an amplifier

- Weight data passes to the alarm system wirelessly

- Sensor weight calibrated on startup



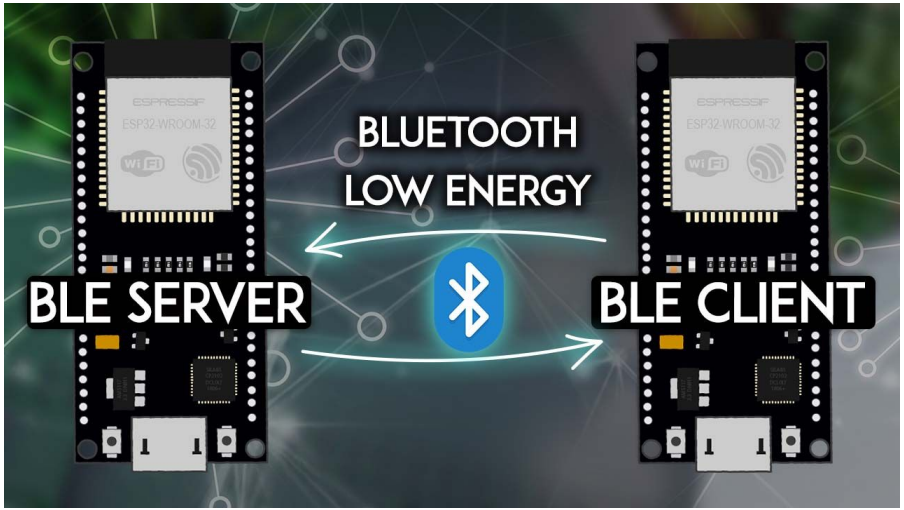
Sensors placed in 3D brackets

Overview: Alarm Clock

Bluetooth Operation

- BLE (Low Energy) output at 2.4 GHz
- Optimal range is 5 - 8 meters
- Weight data received every second.

*BLE has as low as 1% power consumption compared to regular bluetooth



https://i0.wp.com/randomnerdtutorials.com/wp-content/uploads/2021/11/ESP32-BLE-Client-Server.jpg?fit=1280%2C720&quality=100&strip=all&ssl=1

Overview: Alarm Clock

Power

- ESP32 powered by 5V wall plug
- ESP32 outputs 3.3V to pins
- Alarm buzzer operates at a range of 1.5V to 12V
- LED 7 segment display operates at a range of 3.3V to 5V

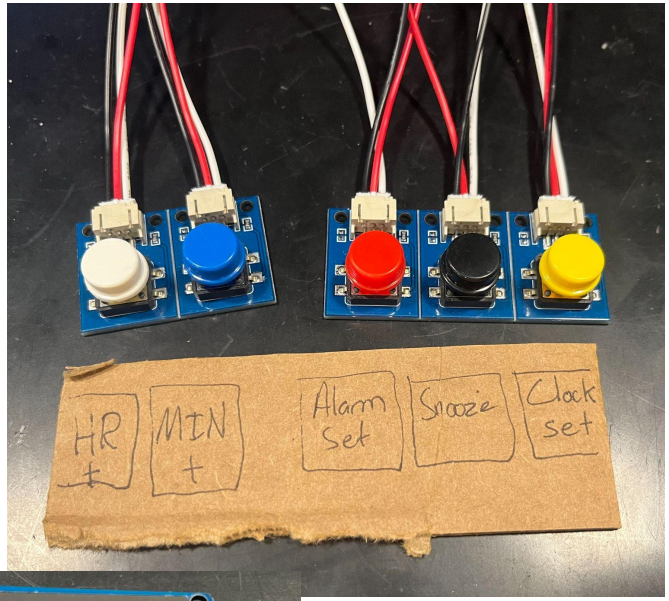
Overview: Alarm Clock

User I/O

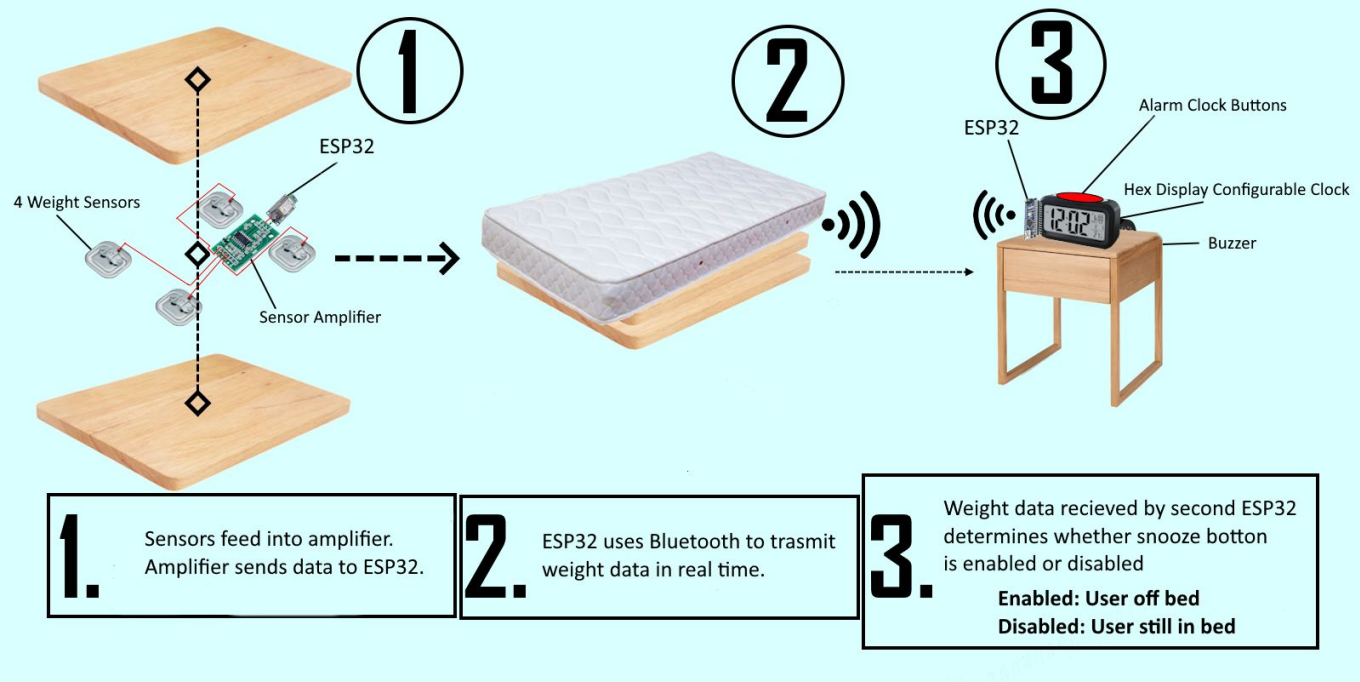
- LED 7 Segment display for clock

- 5 input buttons for clock operation

    - Set Alarm
    - Set Clock
    - Snooze
    - Hour Increment +1
    - Minute Increment +1

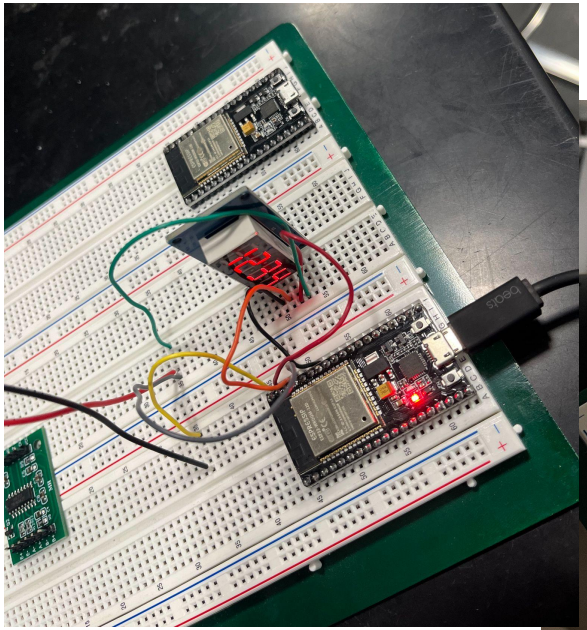


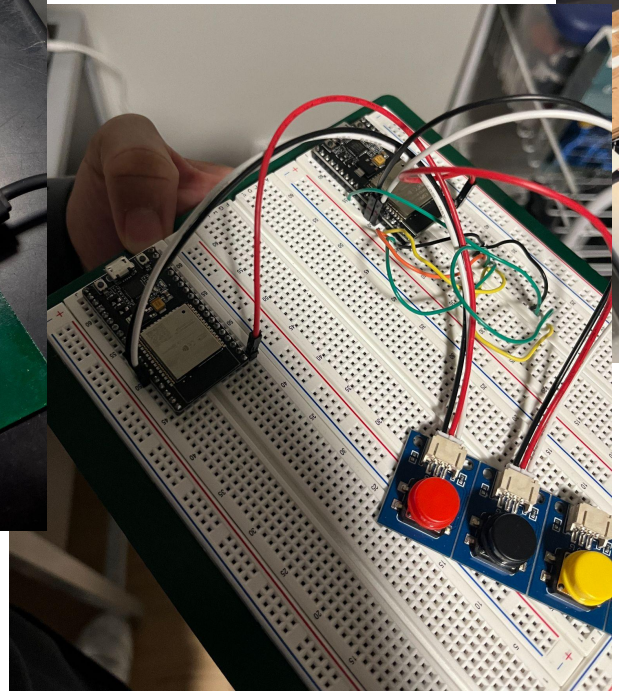
Concept Design

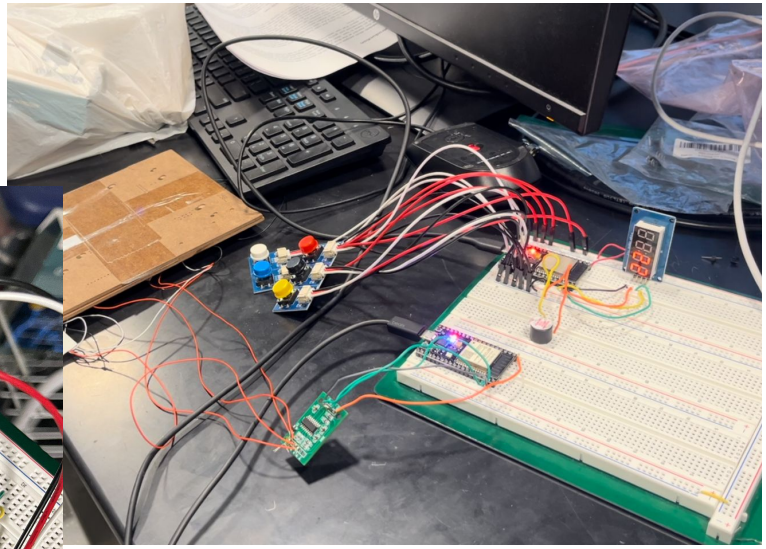


Original Concept Image

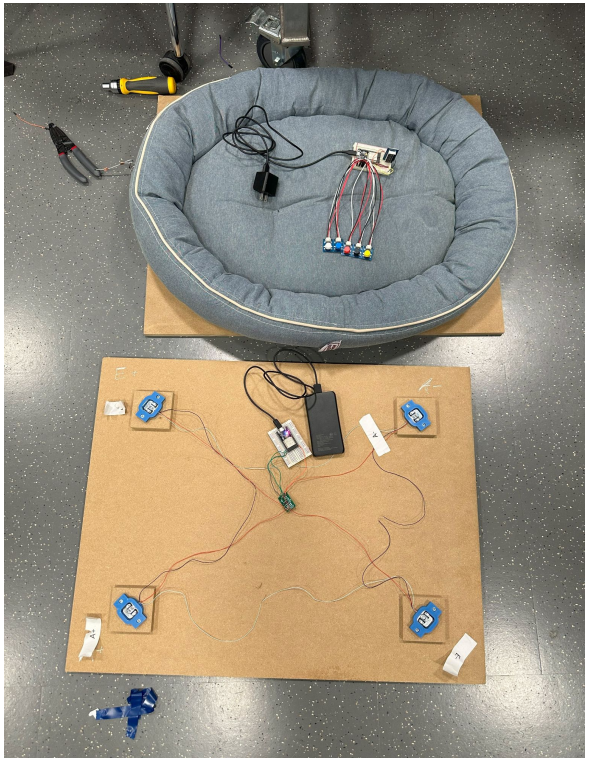
Building Phase

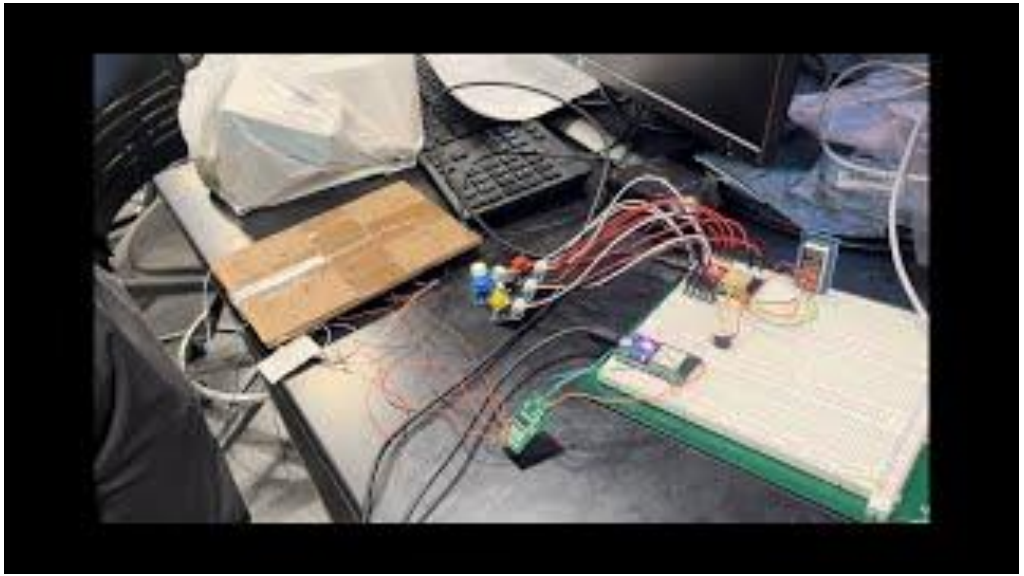






Final Build





*Accelerated clock time
*Shortened timer

Functional Test Results/Verification

Weight Sensor Tests

- Consistency & Accuracy
  - Does it produce consistent and accurate weight data?
- Balance
  - Does the distribution of weight on the board affect readings?
- Real Time Response
  - Can it reliably detect changes in the load placed on it?

Weight Sensors - Test #1

Consistency & Accuracy Test Results

Test Subject	Platform Test #1 (lbs.)	Platform Test #2 (lbs.)	Platform Test #3 (lbs.)	Bathroom Scale (lbs.)	Test Standard Deviation	Percent Difference (Test Average/Scale)
Colby	156	154	154	156	1.154701	99.15%
Ebaad	180	178	181	203	1.527525	88.5%
Syed	188	189	187	192	1	97.92%
Kylie	107	107	107	106	0	100.94%

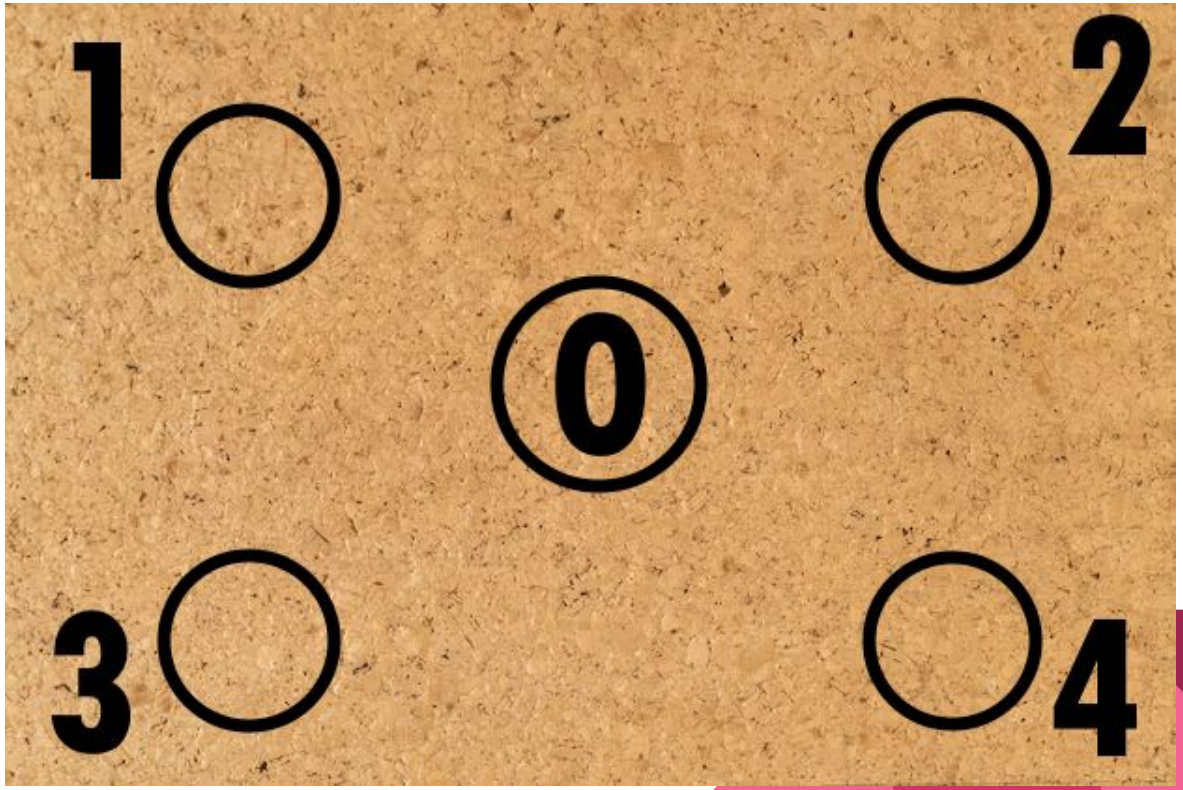
Readings show remarkable consistency.

Accuracy suffers slightly at higher weights.

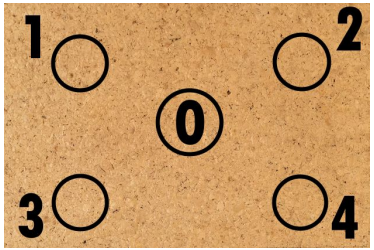
Weight Sensors - Test #2

Balance Test Setup

Test subjects were asked to place feet (and hands!) on various parts of the platform. 8 configurations.



Weight Sensors - Test #2



Balance Test Results

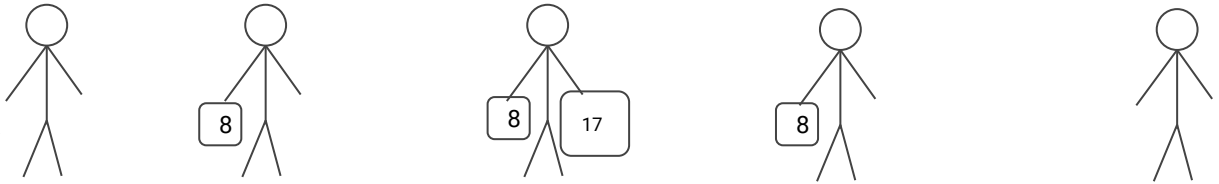
Test Subjects	1&2	3&4	1&3	2&4	2&3	1&4	1&2& 3&4	0	Test Standard Deviation	Test Standard Deviation Without 0
Colby	151	155	155	143	157	155	149	128	9.65752852	4.87950036
Ebaad	160	192	178	161	173	188	192	136	19.4642529	13.7199889
Syed	178	188	185	173	187	189	186	148	13.7710877	5.9361684
Kylie	105	104	107	107	107	107	106	98	3.09088522	1.21498579

Center of the platform seems to bend when testing position 0.

Standard deviation nowhere close to 50 lbs.

Weight Sensors - Test #3

Real Time Test Results



Test Subject	Step on	Grab 8 lbs bag	Grab 17 lbs bag	Remove 17 lb bag	Remove 8 bag
Colby	147	154	165	153	146
	Δ147	Δ7	Δ11	Δ-12	Δ-7

Clearly able to detect changes in real time.

Again, higher weights appear to be a bit of a problem.

Working Test

Bluetooth

- Increment counter on one chip with LED display on the other
    - Random Number generator
    - Real time weight sensor data

Alarm clock

- All members try to “break” alarm
    - Testing clock loops and simultaneous button pressing

Issues Fixed

- Delay of incoming data if alarm changed
- Issue Fixed: Alarm could be set past 60 min

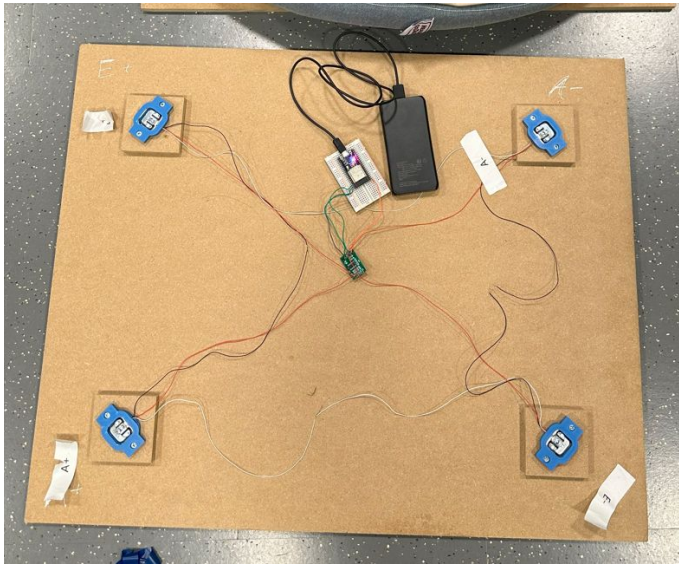
Successes and Challenges/ Failed Verifications

Successes

- Alarm Clock System is configurable with buttons

- Weight sensor show weight in pounds with ~10% margin of error

- Calibration worked in all positions of board



Challenges

- Many components arrived late or not at all.

- Sensors stability → two sensors worked, two don't (works now)

Relevant Ethical Issues

Ethics Concerns:

- Potential copyright and patent issues

- IEEE Code of Ethics sections I and VI, “we will honestly disclose any information and usage of code or data to any of the parties’

- Maintain and improve our technical competence

- Open to advice or criticism and prioritize safety when fixing issues and pay attention to the well-being of everyone.

Floor mat alarm clock

Relevant Safety Concerns

Safety Concerns:

- Issues of getting burned soldering or getting electrocuted
- Any exposed wire or loose components could electrocution
- Flammable mattress could lead to fire
- Alarm system connecting directly to a wall outlet
- Section I of the IEEE Code of Ethics

"We hold paramount, the safety, health, and welfare of the public to strive to comply with ethical design and sustainable development practices."

What We Learned

- Different ways to implement an alarm

- Process of integrating a designed PCB to our project.

- Different types of bluetooth operation and the limitations associated with each

- Optimal ways of debugging code in conjunction with physical hardware components

- Recording varied data with sensors and being able to identity and fix the problem

Recommendations for Further Work

- Integrating our alarm with smart home ecosystems
    - Google Home and Amazon Alexa
- Creating a user-friendly mobile app for monitoring and configuring the bed sensor alarm
    - Mostly useful for patients since tracking there health is crucial
    - Integration with other health monitoring apps
- Incorporate a DFPlayer Chip for programmable audio
- Creating an algorithm for bed movement detection
    - Considering factors like sensitivity and specificity

Special thanks to:

Professor Arne Filfet

TA: Abhisheka Mathur Sekar